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(54) Microprocessor Control of Clothes Washing and Like Machines

(57) A clothes laundering machine includes a microprocessor controlled program selector, in which data representing various laundering programs is stored in a data store, and on selection of a program displays the corresponding program number, program duration, and the ideal value of a variable which affects program duration. A sensor for measuring the actual variable e.g. water temperature is connected to the microprocessor which computes stores and displays a program duration. While program duration calculation is in progress the program duration display flashes. In a clothes washing machine the program duration depends on the difference between the programmed wash temperature and the actual water temperature on completion of the drum-filling cycle. The water is heated to the programmed temperature. The microprocessor keeps the washing machine door locked while the water level is above access door level. A water level sensor is provided.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

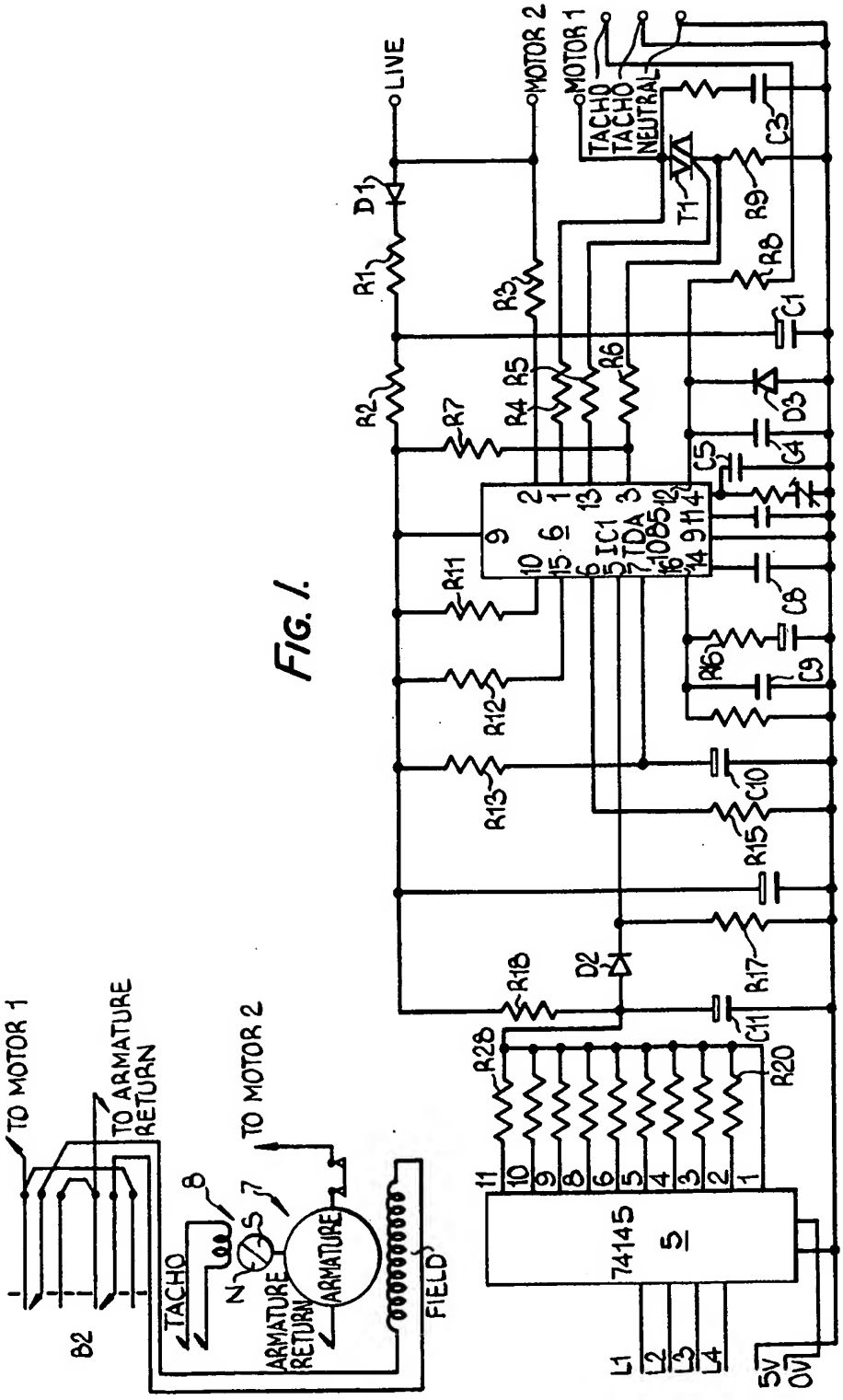
LIVE
MOTOR 2
MOTOR 1
TACHO
TACHO
NEUTRAL
D1
R1
R2
R3
R4
R5
R6
R7
T1
R9
R8
C1
C3
D3
C4
C5
IC1
TDA
1085
R11
R12
R13
R15
C10
C8
C9
R16
R17
D2
R18
R28
R20
C11
74145
L1
L2
L3
L4
5V
0V
TO MOTOR 1
TO ARMATURE RETURN
TO MOTOR 2
B2
TACHO
N
S
ARMATURE RETURN
ARMATURE
FIELD

FIG. 1.

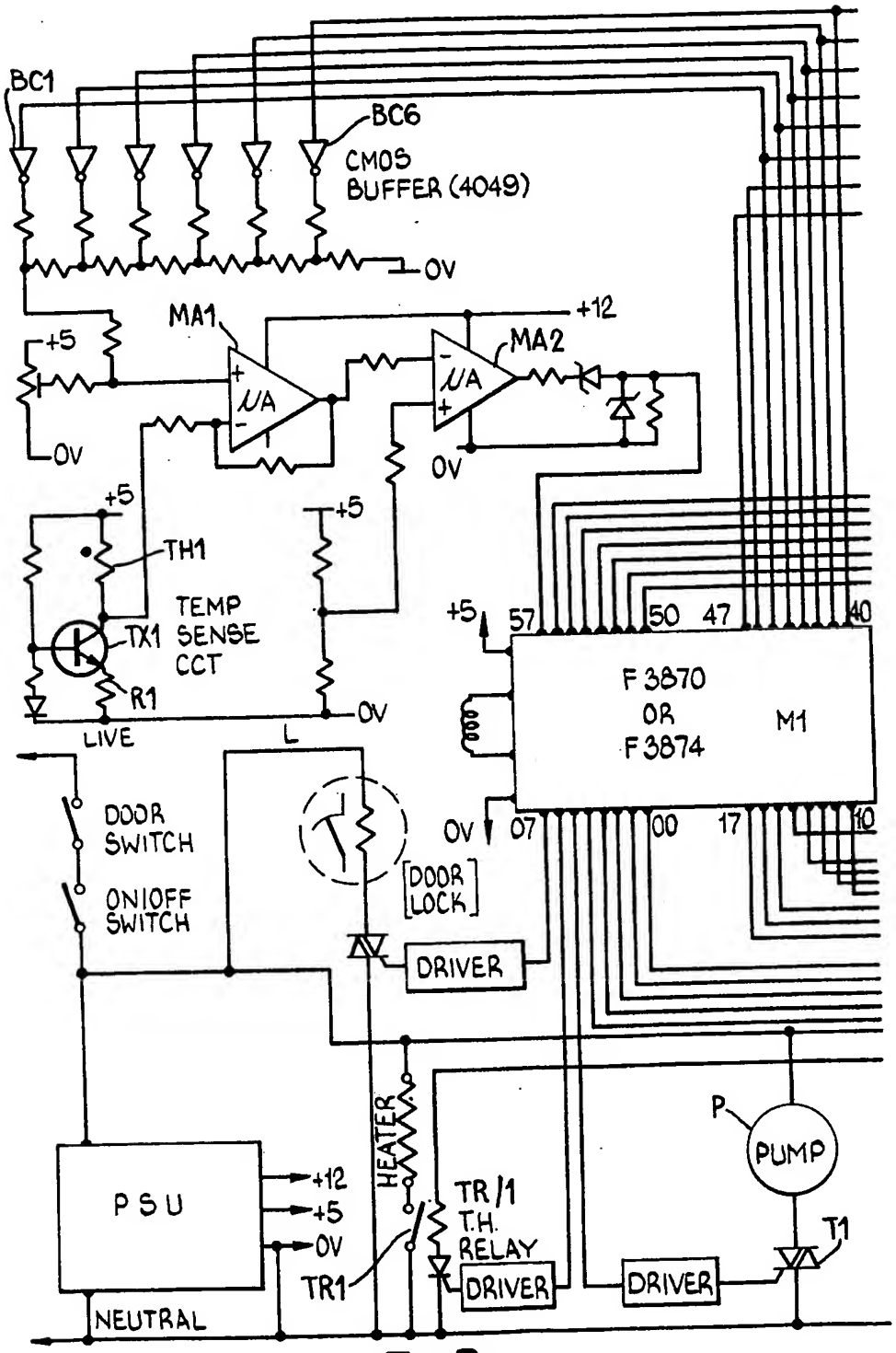
BC1
BC6
CMOS
BUFFER (4049)
0V
MA1
MA2
+12
+5
0V
μA
TH1
TEMP
SENSE
CCT
TX1
R1
LIVE
L
F 3870
OR
F 3874
M1
57
50
47
40
00
17
10
07
DOOR
SWITCH
ON/OFF
SWITCH
DOOR
LOCK
DRIVER
HEATER
TR1
TR/1
T.H.
RELAY
P
PUMP
T1
P S U
NEUTRAL

FIG. 2a.

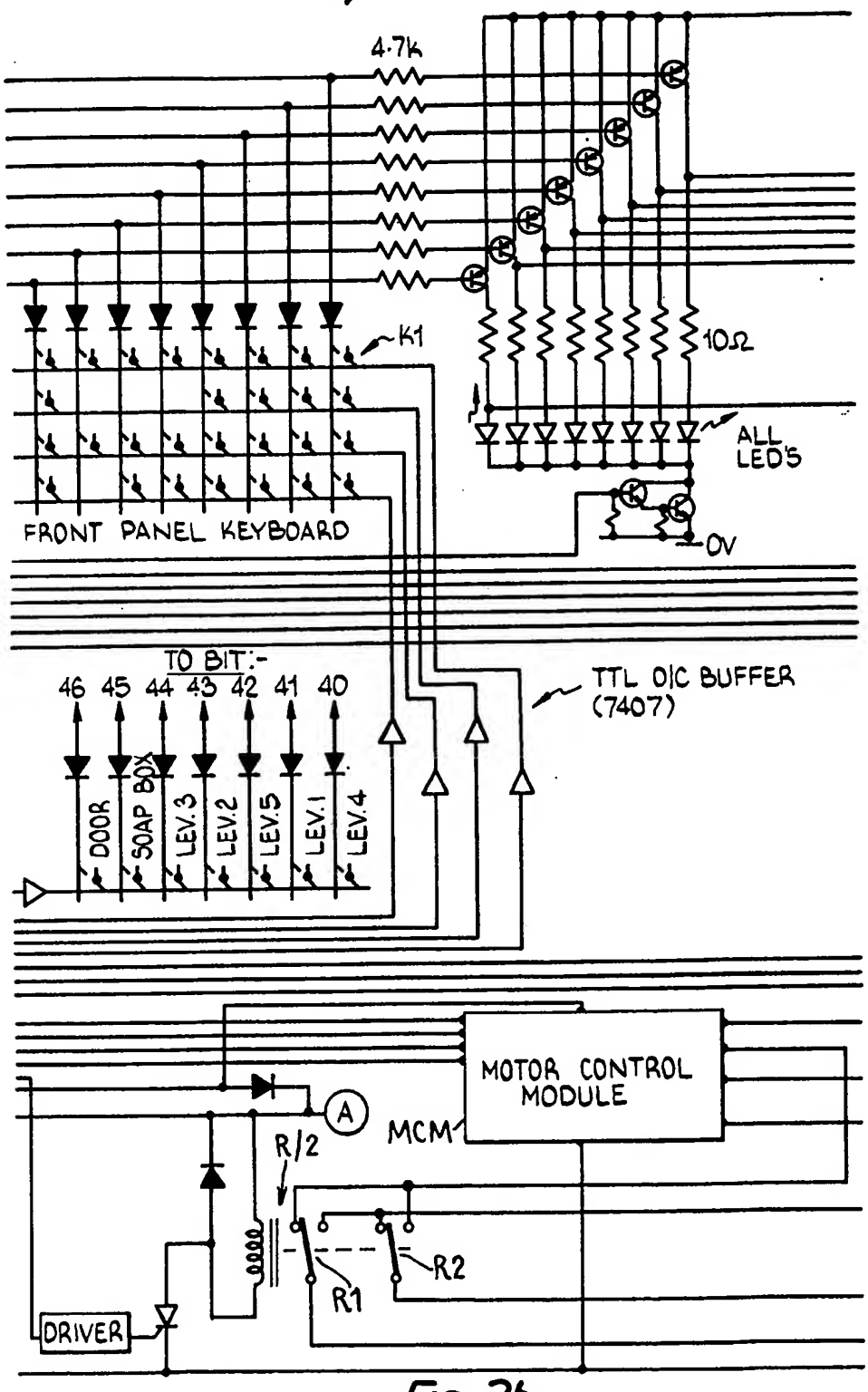
4·7k
K1
10Ω
ALL LED'S
0V
FRONT PANEL KEYBOARD
TO BIT:-
46 45 44 43 42 41 40
DOOR
SOAP BOX
LEV.3
LEV.2
LEV.5
LEV.1
LEV.4
TTL O/C BUFFER (7407)
MOTOR CONTROL MODULE
MCM
A
R/2
R1
R2
DRIVER

FIG. 2b.

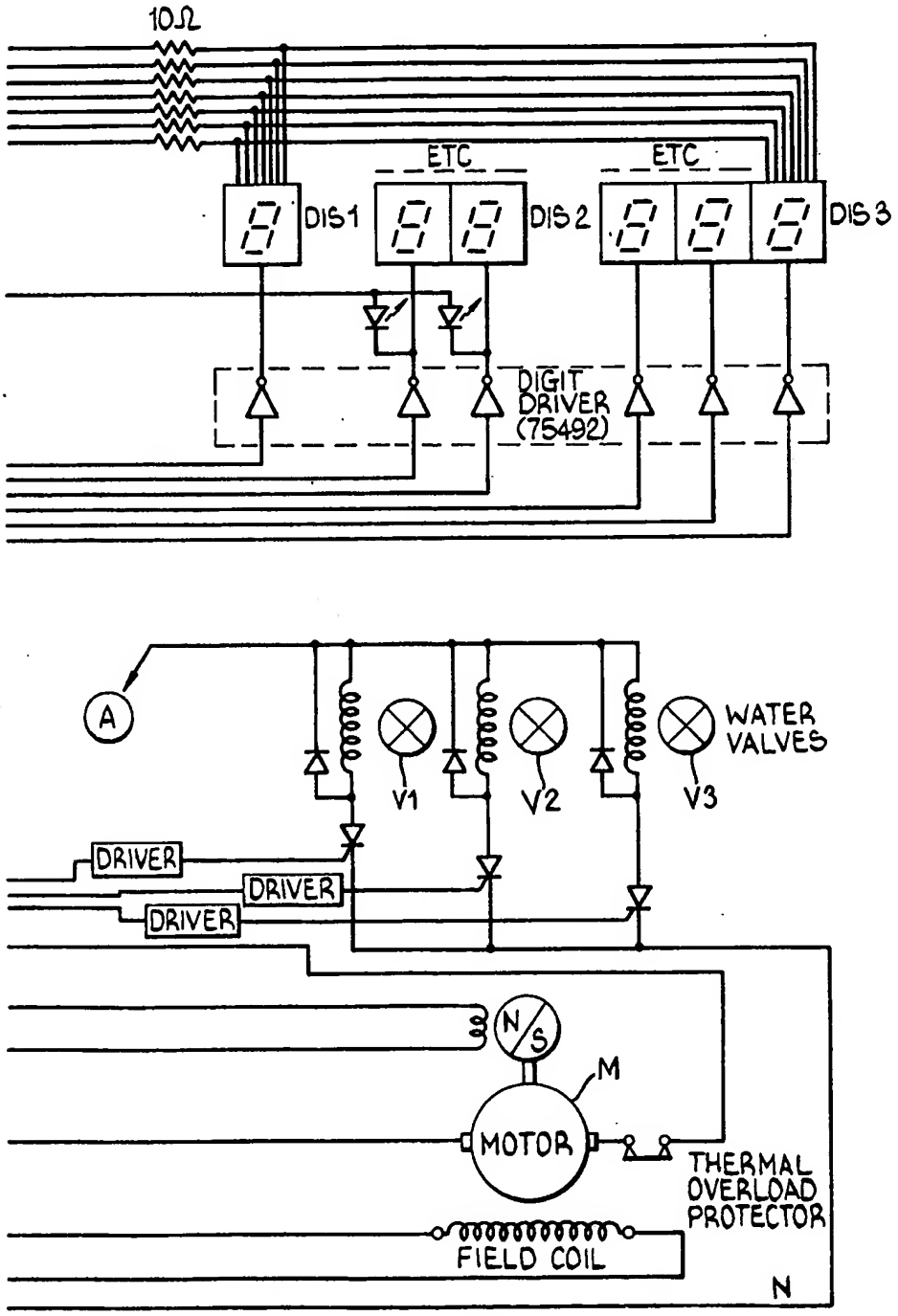
+5
10Ω
ETC
ETC
DIS 1
DIS 2
DIS 3
DIGIT DRIVER (75492)
A
WATER VALVES
V1
V2
V3
DRIVER
DRIVER
DRIVER
N
S
M
MOTOR
THERMAL OVERLOAD PROTECTOR
FIELD COIL
N

FIG. 2C.

SPECIFICATION

Improvements In and Relating to Electric Motor Speed Control Circuits and Apparatus Incorporating such Circuits

This invention relates to electric motor speed control circuits and to apparatus incorporating such circuits and has particular but not exclusive reference to circuits for controlling the speed of universal motors used in clothes washing machines and to such machines themselves.

It is known to control the speed of electric motors by thyristors or triacs, speed control being obtained by varying the conduction angle of the thyristor or triac and hence the power supplied to the motor and thereby the speed of the latter. Feedback giving motor speed is obtained by means of a tacho-generator energised by the motor. Control of the thyristor or triac is effected by a control unit which also provides additional facilities for safety, stability correction, overload protection and may also provide controlled acceleration of the motor when required. The units are designed to operate directly from contacts on a program selector.

It has been proposed to replace the control unit by an integrated circuit which provides all the required facilities and reduces the number of discrete components required and hence constitutes a more reliable and economic alternative. The integrated circuit has, however, been designed to work with a conventional program selector. Thus, if it is desired to replace the conventional program selector by a microprocessor, it is found that commercially available speed control units are not compatible with the microprocessor output. The microprocessor is able to provide control of a greater number of different motor speeds than the conventional unit can deal with, and additionally, the microprocessor is not able to meet the current and voltage requirements of the unit.

Thus, the present invention envisages a microprocessor-controlled motor-speed-control circuit in which an interface unit translates the relevant output of the microprocessor into speed control signals compatible with the requirements of the speed control circuit.

The nature of the interface unit will depend upon the requirements of the microprocessor and if desired or necessary complete isolation of the microprocessor for the higher voltages required by the motor may be provided. This may be achieved in a number of ways, for example optoisolators or relays such as reed relays can be used, where the interface unit employs CMOS technology, high value isolation resistors may provide a sufficient degree of electrical isolation to conform to safety standards.

The interface unit may employ TTL technology, this having the advantage that open collector outputs are available and these permit a substantial change in voltage output level from input to output of the interface unit.

The interface unit may comprise a decoder that receives 4-bit binary coded digits from the microprocessor and translates these into output signals on a selected one of ten output lines.

However, a larger expansion could be achieved if an 8-bit input was available or a decoder translating 4-bit inputs to a selected one of sixteen output lines is used.

The invention also envisages a clothes washing machine employing a microprocessor controlled program selector in conjunction with a speed control circuit incorporating an integrated circuit to vary the speed of the motor driving the drum of the machine and an interface unit that converts the relevant output of the microprocessor into signals compatible with the integrated circuit.

The microprocessor contains both a central processing unit (CPU) and a programme storage unit (PSU). The CPU performs the logic and arithmetic required, i.e. it executes the sequence of programme instructions presented to it. The PSU is a memory whith its own addressing logic which presents the instructions to the CPU. It contains an ordered list of instructions in binary code, i.e. the program or software.

The microprocessor may be programmed to cycle the washing machine through each of a number of different washing programs identified by the different keys of a keyboard control unit operable by a user to select a required program.

A display unit is provided which indicates the number of the program selected, the water temperature at which washing takes place and the estimated time that the program will take. Water temperature sensors are provided that sense the temperature of water fed into the machine and via the microprocessor that information is used to correct the estimated program time if necessary.

The water temperature required by any particular program is written into the microprocessor but the actual temperature of water entering the machine may not correspond with the temperature required by the program. The temperature of water entering the machine is monitored and during monitoring, the display "flashes" to indicate to a user that the actual program time has not yet been determined. At the end of the filling stage, the display steadies at a value determined by the temperature of the water in the machine.

A door interlock also controlled via the microprocessor may be provided so that a user cannot open the door giving access to the drum if either the drum is rotating at a dangerously high speed or if the machine contains water at a dangerously high temperature or water at a level giving rise to the risk of water flow from the machine if the door is opened. At the end of a program, the door may be held locked for a short period of time and then unlocked, the unlocked condition being indicated by signal lamp or a "flashing" display.

By way of example only, a motor speed control circuit and a clothes washing machine control circuit embodying the features set out above will

now be described in greater detail with reference to the accompanying drawings of which:—

Fig. 1 is a diagram of a motor speed control circuit, and,

Fig. 2 is a diagram of the clothes washing machine control circuit.

The speed control unit shown in block schematic form in Fig. 1 receives control signals from a processor which may be of Type F3870 or F3874 over input leads L1, L2, L3, L4. Those leads together with supply voltage input to pins 15, 14, 13, 12, 16 respectively of an interface unit 5 which in this embodiment is a Type SN74145 open-collector BCD to decimal decoder.

Each valid unique input code applied to the interface unit will select one only of the ten output leads and in the case of outputs 2—11 will, in effect, cause one only of the resistors R20—R28 to be connected in parallel with resistor R17. Thus, a particular potential is applied to pin 5 of integrated circuit 6 which, in this embodiment, is Type TDA 1085. The applied potential is directly related to the motor speed required.

If output pin 1 of unit 5 is selected, the resultant small voltage that appears because of the saturated collector to emitter voltage by virtue of the current through R18 is not passed to pin 5 of integrated circuit 6 because it is less than the forward conduction voltage of the diode D2. Output pin 1 represents the "stop" condition of the motor. In this case, the potential applied to pin 5 is that set by the R17, R18 combination. In addition, invalid codes applied to leads L1 ... L4 switch all the outputs of the unit 5 to a high impedance state with the result that the potential applied to pin 5 is that determined by the R17, R18, D2 combination, and this corresponds to the maximum motor speed.

Other inputs to the pins of integrated circuit 6 follow the manufacturer's instructions.

Fig. 1 also shows the motor 7 driving the drum of the clothes washer. The motor is energised as shown via switch B2 which is a reversing switch controlled by a relay not shown in the drawing.

Power applied to the motor is controlled via triac T1 whose conduction angle is determined by integrated circuit 6 via output pin 13. Tacho-generator 8 provides an input to pin 12 of the integrated circuit and voltage and current synchronization is provided in the manner shown in Fig. 1.

The speed control circuit just described has particular application to clothes washing machines but may also be used in other apparatus.

Fig. 2 shows the circuit diagram of a clothes washing machine incorporating the speed control circuit of Fig. 1.

The machine is of conventional physical construction which will not be described herein.

Operation of the machine is controlled by a microprocessor shown as block M1 and which may be of Type F 3870 or F 3874 programmed to cycle the machine through the stages of each of a number of different washing operations each of which is identified by a different key of a keyboard K1.

The keyboard may take any known form and its contacts are scanned cyclically by the microprocessor to detect operation of one of the keys. Once a key is depressed, the washing operation identified by the selected key is addressed and is brought into operation when the user actuates a "start" button.

Alternatively, a set of touch pads may be used instead of keys that have to be depressed by a user.

The programs may be identified by the temperature at which the clothes are washed, an indication of that temperature appearing on the key or touch pad instead of a program number.

On actuation of a selected key, the selected program is identified by the appearance of the appropriate digit in display DIS1, the washing temperature in degrees Centigrade appears in digital form in display DIS2 and the probable time to cycle the machine through the selected program is shown digitally in minutes by display DIS3. As explained above, as water enters the machine during the filling stage of a washing operation, the program time display flashes indicating that the temperature of water entering the machine is being monitored and the final program time has not yet been determined. At the end of the filling stage, the program time display steadies at a value determined by the temperature of the water now in the machine.

The displays are of the conventional 7-segment type and are controlled in known manner by the microprocessor.

Electromagnetically operated water flow control valves V1, V2 and V3 control respectively the flow of hot water, cold water and fabric conditioner into the machine. Energisation of the electromagnets is effected via thyristors and drivers from the microprocessor as shown. Water is pumped from the machine by a pump P powered via a triac T1 controlled via a driver from the microprocessor.

During certain washing operations, the direction of rotation of the drum is reversed and this is effected by contacts R1, R2 of relay R/2. Energisation of relay R/2 is controlled by a thyristor from the microprocessor via a driver.

The microprocessor also receives information, at the appropriate stages, from pressure activated level switches responsive to water levels in the washing machine, and from microswitches indicating the open or shut condition of the soap box and the door that gives access to the drum of the machine. The switches are scanned cyclically from the microprocessor to determine the state of each switch.

A heater H1 is included and is energised via a thyristor controlled from the microprocessor via a driver when the temperature of water within the drum is below that required by the selected program. The thyristor energises a relay TR/1 which may be of the thermal type and whose

contact TR1 is in series connection with the heater H1. The relay TR/1 and its contact may be replaced by a triac.

Motor M driving the drum of the machine is speed regulated via the circuit shown in Fig. 1 and which, in Fig. 2, is represented by block MCM.

The temperature of water in the drum is sensed by a thermistor TH1 connected in a potentiometer configuration with a transistor TX1 and resistor R1 which comprises a constant current generator. Changes in potential at the interconnection of thermistor TH1 and transistor TX1 are passed to operational-amplifier MA1 where a comparison is made with preset potentials derived from buffer circuits (Type 4049) BC1 ... BC6 scanned cyclically by outputs from the microprocessor. Difference potentials from MA1 are fed via a second operational-amplifier MA1 back to the micro-processor where they are used to control the energisation of heater H1 and to update the estimated program time displayed by display DIS3 as explained above.

In a typical program, the microprocessor having been directed by operation of a key of keyboard K1 and signalled to start, operates first to open the hot water inlet to allow water to flow into the drum up to a predetermined level.

After a short time interval motor M is energised to rotate the drum at 50 r.p.m. for two minutes. The motor being stopped and then reversed and then restarted periodically during the two minutes, so providing what is conventionally referred to as "normal agitation". After a short period the motor M is again energised to rotate the drum at 40 r.p.m. to give a "gentle" agitation of clothes in the drum, this involving reversal of the direction of rotation of the drum. At the same time the heater is energised to heat the water in the drum to 50°C, if the incoming water is below that temperature.

When that temperature is reached, the motor is again energised to rotate the drum at 50 r.p.m. with "normal agitation" for a period of thirty minutes during which time the heater is energised to increase the water temperature to 95°C.

At the end of the thirty minutes, cold water is admitted to bring the water temperature down to 75°C or cold water is admitted until the level inside the drum reaches another preselected level.

The water is then pumped out and the motor speed is gradually increased to bring the drum speed to 84 r.p.m. to distribute the clothes evenly inside the drum. This operation takes about 40 seconds.

There then follows a series of rinsing operations. At the commencement of the first of these hot and cold water is admitted, the drum is rotated at 50 r.p.m. with "normal agitation" after which the water is pumped out and the motor speed is gradually increased to 84 r.p.m. to distribute the clothes prior to a spin operation at a drum speed of 600 r.p.m. for 15 seconds. During that time the pump is operated to pump out from the machine water extracted from the clothes during the spin operation.

Three subsequent rinses then occur, the machine filling, in each operation, with cold water only.

Then follows five spin sequences at increasing drum speeds. During the first of the spin sequences, a drum speed of 350 r.p.m. is employed for 3 seconds during the course of which the pump is operated to pump from the machine water expelled from the clothes during the spin. The pump continues to operate for a further 10 seconds after which the clothes are periodically tumbled in each direction of rotation at a drum speed of 50 r.p.m. for 40 seconds. The drum speed is then gradually increased to 84 r.p.m. for 10 seconds to distribute the clothes during which time the pump is also operated.

The four subsequent spin sequences employ spin speeds of 450, 600, 750 and 850 r.p.m. for periods of 5, 10, 20 and 40 seconds respectively, but are otherwise similar to the first sequence except that the pump is energised for a correspondingly longer period after each spin period.

There then follows a high speed spin with the drum rotating finally at say 1200 r.p.m. for 4 minutes. The final spin speed may be achieved in a number of discrete speed steps with a slight pause at each step. At the end of that period pumping continues for another 40 seconds after which the clothes are tumbled at a drum speed of 50 r.p.m. with periodic reversal for a period of 80 seconds.

Finally, after a preselected time delay the door catch is released so that a user may open the door and remove the clothes, this condition being indicated by the energisation of a signal lamp.

Other programs provided by conventional washing machines are also written into the microprocessor.

The invention can also be embodied in laundry appliances other than washing machines. Thus tumbler dryers have drying cycles whose duration depends upon several variables, for example, ambient air temperature, weight of articles to be dried, the "wetness" of the articles to be dried, the material of which the articles are made. A microprocessor for use with a tumbler dryer may be programmed to provide a series of "standard" drying cycles, an appropriate cycle being selectable by a user via, for example, a push or touch button control panel. On selection of a particular program, the standard "time-to-run" would be displayed visually and then modified accordingly to one or more of the variables referred to above, the particular value of the variable being detected by a suitable detector and transmitted to the microprocessor which modifies the displayed time as necessary.

A similar concept can be applied to a spin dryer.

Where a washing machine also includes "tumble dry" facilities these may be controlled in the manner indicated above.

Claims

1. A clothes laundering machine including a rotatable drum into which articles to be laundered are placed, an electric motor for rotating the drum, an integrated circuit control unit for controlling the electric motor, a microprocessor connected to a program selector and adapted to respond to an indication from the program selector of a program selected by a user, by operation of the selector, and to cycle the machine through the selected program, and an interface unit connected between the microprocessor and the integrated circuit for converting motor speed control signals generated by the microprocessor into a form compatible with the requirements of the integrated circuit.

2. A machine as claimed in claim 1 in which the speed output signals generated by the microprocessor comprise binary coded digits and in which the interface unit comprises a decoder for translating the binary coded digits into a unique output on one of a plurality of output lines from the decoder.

3. A machine as claimed in claim 1 or 2 and further comprising an access door which, when opened gives access to the interior of the drum, and a door interlock for locking the door in its closed position at the commencement of a cycle, the microprocessor being adapted to control the interlock so as to prevent opening of the door in the event that the drum is rotating at a speed above a predetermined speed and when the machine controls water whose temperature exceeds a predetermined value.

4. A machine as claimed in claim 3 in which the interlock is released only after the expiry of a predetermined time delay following the end of a program.

5. A machine as claimed in claim 3 or 4 in which the release of the interlock is indicated by a visual signal.

6. A machine as claimed in any one of the prceding claims in which the program selector comprises a keyboard.

7. A machine as claimed in any one of the preceding claims in which the selector includes a "START" control operation of which initiates operation of the machine through the selected program.

8. A machine as claimed in any one of the preceding claims and further comprising a visual display unit controlled by the microprocessor for displaying an indication of the selected program.

9. A machine as claimed in claim 8 in which the visual display unit also indicates the water temperature required by a selected program and also the estimated time to cycle the machine through the selected program.

10. A machine as claimed in claim 9 in which the display indicating the estimated time is adjusted by the microprocessor in accordance with the values indicated to the microprocessor of variables affecting that time and which are monitored by sensors inputting to the microprocessor, the time display changing in appearance when the microprocessor has completed its adjustment of the estimated time.

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